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Detection of Delamination in A Composite Beam By Using Vibration Analysis

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ABSTRACT:

Delamination is the separation of layers which are fortified together in composite cover. It is a typical harm in fiber strengthened composite overlays, normally avoided outer view. On account of bowing burdens delamination as a rule prompts critical loss of twisting firmness and quality. Accordingly, it is essential to distinguish the nearness of delamination at a beginning time on the grounds that early harm discovery assumes a critical part to ensure security and unwavering quality of in-benefit structures. The delamination causes diminishment of solidness and in this manner the modular frequencies likewise change. In this work modular investigation is utilized to decide the delamination in the composite structure. This is finished by making a four-layer multi directional overlay of E-Glass/Epoxy in ANSYS 15.0. A parametric report is led by changing length of the delamination in the center layer by shifting limit conditions. The outcomes got from the numerical displaying is approved with the outcomes acquired from the explanatory demonstrating in view of the transverse vibration of the composite shaft for the settled free, basic, settled limit conditions.Harmonic analysis is done to observe the resonating and anti-resonating peaks for the intact composite beam and delaminated composite beam with fixed-free, simple-simple, fixed-fixed boundary condition. Amplitude values of the beam also obtained from this harmonic analysis by varying the length of the delamination for the beams with different boundary conditions

Key words: *Delamination, E-Glass/Epox Ansys, Harmonic analysis etc.*

I.INTRODUCTION

Composites have better applications compared to traditional metals however they are very sensitive to the damages caused during their fabrication or service life. The common failure mode occurred in the layered composite is delamination. It is the separation of layers which are bonded together in composite laminate. It may occur due to imperfect fabrication process, incomplete wetting, air pockets entrapped between layers, loss of adhesion between two laminates, material discontinuity, mechanical loading, or certain in service factors, such as low velocity impact by foreign particles. Due to this delamination present in the structure causes the reduction in the stiffness and strength of the composite structure. This reduction in stiffness directly affected the vibration characteristics of the composite structure, such as natural frequency and mode shapes. Reduction in stiffness results to changes in natural frequency; this reduced frequency sometimes closes to working frequency of the system it leads to resonance.

II. PROBLEM STATEMENT

Now a day's many researchers shows the interest on dynamic modeling of flexible delaminated layer beams because use of laminated composite structures increasing day by day so that the requirement for accurate delamination models also increasing. The common delamination problem observed in composite beam is vibration of laminated layers, which means the upper and lower intact portions of the delaminated segment to vibrate freely independent of each other under free mode condition. In addition, delamination is caused by improper or imperfect bonding, crack in material, chemical corrosion, and separation of joined tiles or broken fibers during manufacturing. Some of these failures may attribute to in-service loads, which are caused by object impact or fatigue. When delamination occurs in a structure, the bending stiffness at that cross section of the material decreases and in turn, the natural frequency decreases. A small change in the value of natural frequency is a great indicator to identify that delamination has occurred. Since frequency is proportional to the square root of stiffness, a small variance in frequency would mean a large damage to stiffness of the composite. It should be note that the reduction in stiffness and natural frequency depends on the size and location of the de-bonding of material.

III. MODAL ANALYSIS USING ANSYS

In present work analytical modal analysis was performed for beams having rectangular cross-section of dimensions 250 mm x 50 mm x 5 mm with a four-layer multi directional laminate composite beam of E-Glass / Epoxy ($90^0/0^0/0^0/90^0$) in ANSYS 15.0. This is done by creating middle layer delamination by varying the length of the delamination with various boundary conditions like fixed-free, simple-simple-simple and fixed-fixed.

ANSYS 15.0 is used for performing modal analysis using finite element modeling to our present work. ANSYS 15.0 is engineering simulation software based on finite element method used to obtain solutions to large class of engineering problems involving stress analysis, heat transfer, electromagnetism and fluid flow. In ANSYS 15.0, ANSYS Workbench is used for simulation due to its interface with most of CAD packages. CATIAV5 R20 (Computer Aided Three-dimensional Interactive Application) is used as CAD package to develop geometric models for various cases of problem.

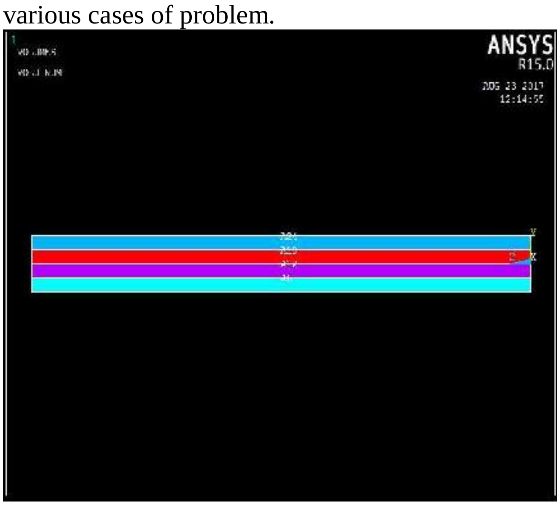
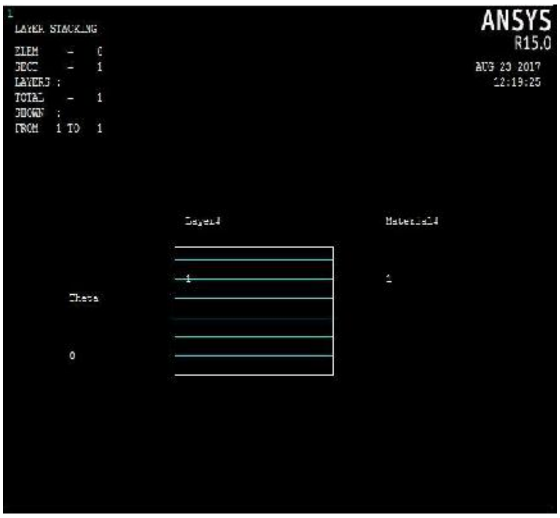


Fig-1 Modeled laminated composite beam with four sub laminates



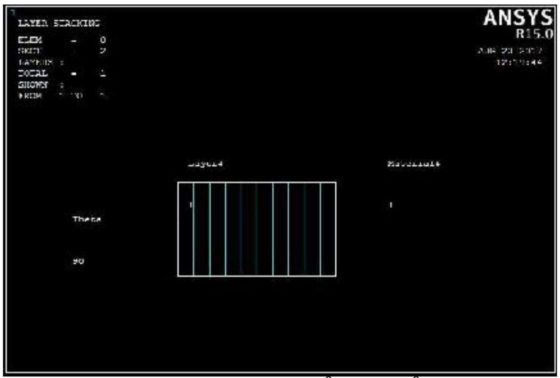


Fig-2 Layer stacking with 0^0 and 90^0 with fiber orientation

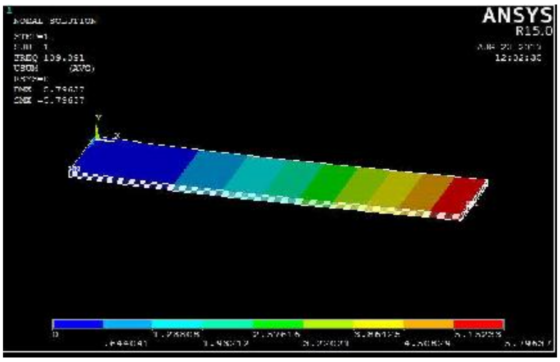


Fig-3: First mode shapes of the intact and delaminated beams with fixed-free boundary condition

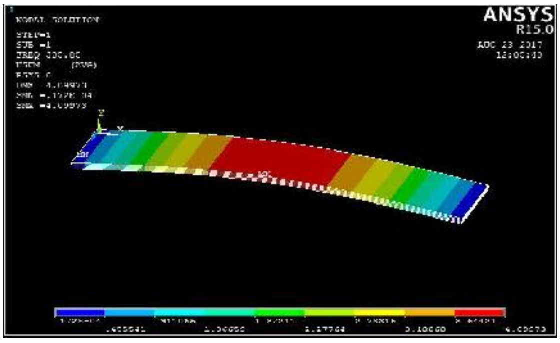


Fig-4: First mode shape of the intact and delaminated beams with simple-simple boundary condition

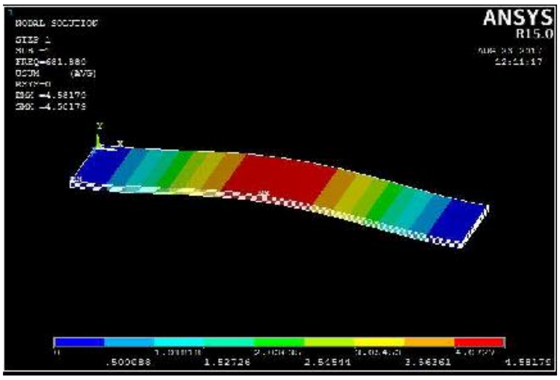


Fig-5: First mode shape of the intact and delaminated beams with fixed-fixed boundary condition

IV HARMONIC ANALYSIS

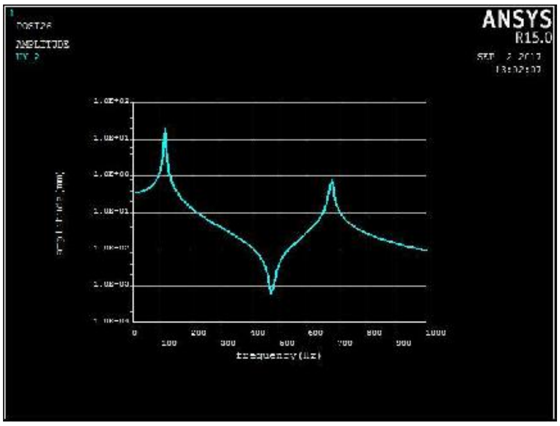


Fig-6: Frequency response of fixed-free intact composite beam

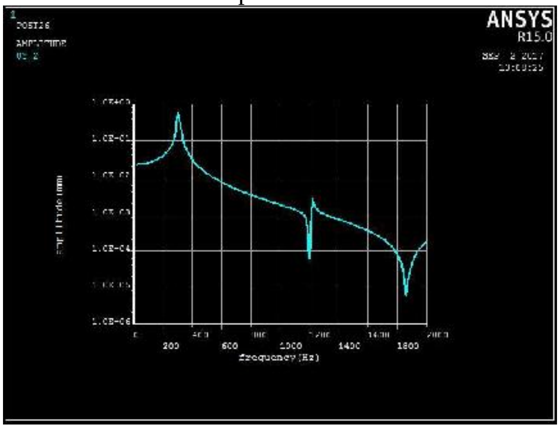


Fig-7: Frequency response of simple-simple intact composite beam

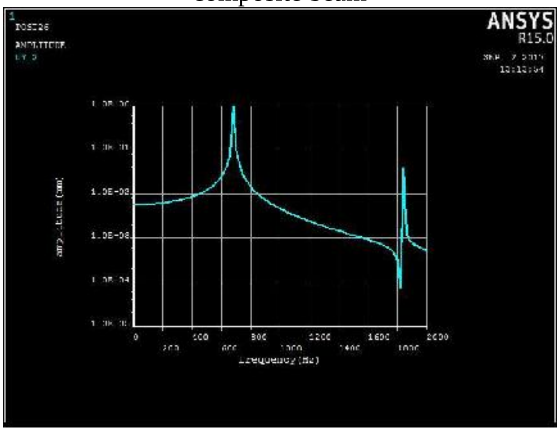
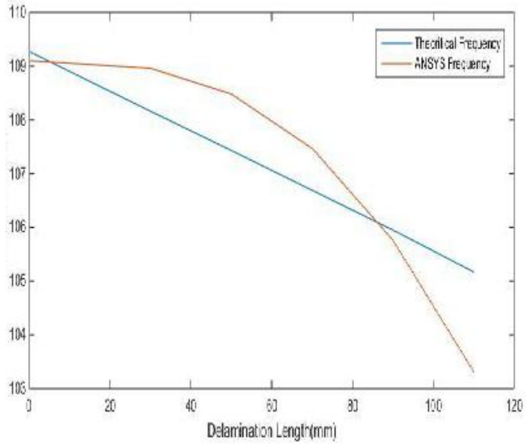


Fig-8: Frequency response of fixed-fixed intact composite beam

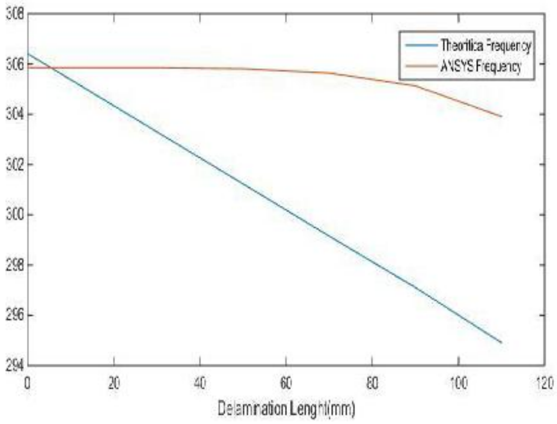
V.RESULTS AND DISCUSSIONS

In the present work the natural frequencies of the intact and delaminated composite beams with various boundary conditions are obtained by conducting modal analysis using ANSYS 15.0 software. The theoretical natural frequencies of intact beam and delaminated beams are also obtained from the formulae with the help of MATLAB Software, later harmonic analysis is carried out.

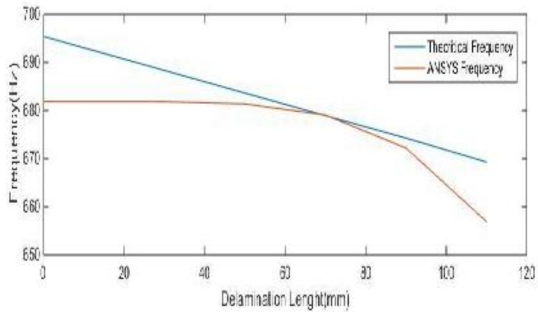
The following graphs shows comparison between the First mode Theoretical frequency and ANSYS Frequency with various delamination length for the fixed-free, simple-simple, fixedfixed boundary conditions. From this graphs it shows that natural frequency is decreasing with increase in the length of the delamination.



Graph-1: First mode frequencies of Theoretical calculations and ANSYS VS Delimitation length for the beam fixed-free boundary condition.



Graph-2: First mode frequencies of Theoretical calculations and ANSYS VS Delimitation length for the beam simple-simple boundary condition.



Graph-3: First mode frequencies of Theoretical calculations and ANSYS VS Delimitation length for the beam fixed-fixed boundary condition

Based on the results obtained for identification of delamination in a composite beam with fixed-free, simple-simple and fixed-fixed boundary conditions the following conclusions are drawn.

1. Due to the changes in the length of delamination in the composite beam there is always a change in the natural frequencies.
2. The results obtained during the vibration analysis of intact beam and beam with
delamination for the different boundary conditions in the modal analysis using ANSYS is good agreement with results obtained from the theoretical calculations
for the same boundary conditions.
3. From the inspection of the mode shapes of the intact beam and delaminated beams
for the three boundary conditions the magnitude of the deviation of the mode shape increases with increase in length of the delamination.
4. Natural frequencies obtained for the intact beam is greater than the natural
frequencies of the beams with delamination for the fixed-free, simple-simple, fixed-fixed boundary conditions.
5. Natural frequencies decreases with increasing length of the delamination for the fixed-free, simple-simple, fixed-fixed boundary conditions.
6. For the smaller delamination lengths separation of layers can be observed at higher mode frequencies and for the higher delamination lengths separation of layers can be observed at lower mode of frequencies for the fixed-free, simple-simple, fixedfixed boundary conditions.
7. The resonating and anti-resonating peaks are obtained from harmonic analysis. The natural frequency values obtained by the two modes are verified using harmonic analysis.
8. For higher lengths of delamination it is observed that the difference between the
second mode natural frequency of the theoretical calculations and ANSYS is very high.
9. The amplitude corresponding to the highest harmonic frequency decrease in the case of fixed-free boundary conditions, increase in -the case of simple-simple
boundary condition and in the first increase and later decrease in the case of fixedfixed boundary condition with increase in length of the delamination.

VI. FUTURE SCOPE

The work may be extended for multiple delamination detection in composite beams, plates and shells. More robust hybrid techniques may be developed and employed for delamination detection in vibrating composite structures in aerospace industries, turbine blades, ship building industries etc. The artificial intelligence techniques may be developed and integrated with the vibration systems to make online condition monitoring easier.

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